LIMITED CIRCULATION

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Agricultural Memorandum No 985

Methods for Estimating Monthly Rainfall Totals

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Introduction

There is frequently a need to estimate monthly rainfall totals for places where daily or monthly rainfall is not measured. There are several different methods which may be used but all will commonly contain errors of ± 15% or more due to the variation of rainfall across relatively short distances. This is especially true if the month has experienced showers or thunderstorms or where there are large altitudinal differences within a few kilometres of the site.

Techniques designed to produce area values are described, which, through representing the local general rainfall will permit point estimates to be made which are suffficiently accurate for activities which are not sensitive to the precise rainfall value.

Although the area rainfall can be estimated fairly accurately there are no techniques which will take account of unrepresentative falls which are much larger or smaller than the area value. The more obvious solution of installing a raingauge is not practical when there are many sites or when only one site is specified after the particular rainfall event has occurred.

Methods

Four areas in England covering a wide range of average annual rainfall (AAR) values and altitudes were selected. The monthly rainfall records from up to three raingauge sites, 2 to 9 km from a central meteorological recording site, included for verification purposes, were examined in each area. The period of the analysis is from October 1982 to June 1983. Limited reference to a five year period did not alter the results appreciably.

Method 1 - 1 near neighbour

For each area the single nearest raingauge to each met. site was selected. The site details are listed in Annexe A, where it can be seen that there were often large differences in altitude and/or AAR even between the nearest sites.

To compensate for any systematic differences between the two sites a weighting factor of the AAR for the met. site to the AAR of the nearby site was used.

Over the 21 month period the accuracy of this method varied widely from a monthly mean error of 7.4%* (Newport) to 14.6% (Macclesfield), with the two largest errors coinciding with the two sites which have an AAR of over 900 mm, see table 1. The average error over all four areas is 10.5%. This masks a large seasonal variation with the summer errors being larger than those in winter and is due in part to occasionally large percentage errors in low rainfall months as well as the problems arising from often predominantly showery weather during the summer.

* Percentage errors are calculated without regard to the sign of the error. Bias in the results is discussed elsewhere.

Despite being extremely easy to operate there are drawbacks. Unless the rainfall recorder at the chosen site can be approached directly there will be a delay of around six weeks after the end of each month before the data can be made available. This allows time for the daily values to be sent to the Met. Office HQ for archiving and quality control. If the site is unreliable the data may well be late or missing, in which case the next nearest gauge with data will be substituted automatically.

Two variations on this method were tested. Firstly the monthly rather than annual, rainfall averages were used in the weighting factor. The extra computation involved did not prove worthwhile with the mean monthly error increasing marginally to 11.3%. Greater difficulty would normally be encountered in estimating the monthly average values as opposed to the AAR which is a reasonably easy and accurate exercise.

Secondly the variation of error with increasing distance from the met. site was tested by repeating the calculation with data from the farthest of the three raingauge sites, and using the appropriate AAR weighting factor in each case. Additional reference was made to monthly data from two raingauges at Rothamsted which are only 100 m apart. The trend of increasing uncertainty with increasing distance becomes clear from the data in table 2.

Table 2 Mean percentage errors at varying distances from a "trial site"

Record and Period	Distance Apart	Mean monthly error (%)
Rothamsted 1972-77	100 m	3.2
4 areas combined 10/81-6/83	2-3 km	10.5
" " " " "	7-9 km	14.5

In all cases the AAR weighting factor reduced the disparity between the records and restricted any bias to under $\pm$ 5%.

Method 2 - 3 near neighbours

This method is designed to produce a weighted average rainfall value for a small area. Each of the three surrounding sites is given the weighting of AAR_{ts}/AAR_1 where AAR_1 is the average from gauge 1 etc, giving in the case of Newport

$$R_{ts} = [0.91 R_1 + 1.08 R_2 + 0.95 R_3]/3.$$

Of the methods tested this gave the best overall accuracy with a monthly mean error of 9.2%, due to the improved accuracy of the area estimate compared to that in Method 1 (see table 3).

Against this however, must be placed the inconvenience of having to process three sets of values, some of which may again be late or missing.

Table 3 Mean monthly percentage errors (by area)

Area	Method			
	1	2	3	4
Newport	7.4	8.6	17.2	19.4
Preston	10.8	10.4	12.0	8.2
Wellesbourne	9.1	7.9	14.9	7.7
Macclesfield	14.6	10.0	12.3	9.7
Overall mean	10.5	9.2	14.1	11.3

Method 3 - MORECS monthly rainfall

Each month a summary of meteorological recordings is produced by the otherwise weekly MORECS* service (see Annexe B). The information is presented on a 40 x 40 km grid square basis and is adjusted to the average height of each of the squares. An associated grid square AAR is also available, which allows a monthly value to be expressed as a ratio and corrected for higher or lower rainfall areas.

Given the relatively low density of daily recordings available to be included in the service the accuracy of its rainfall estimates is less good than the other methods examined. After employing a similar weighting factor, AAR ts /AAR grid sq. to each of the monthly values a mean error of 14.1% was calculated.

The main advantage in this method is the prompt receipt of the data which is issued within one week of the month end. Additionally, an improvement in the accuracy of the estimates may be expected as either more point data is included or the possibility of including radar derived rainfall amounts is researched.

(* The Met. Office Rainfall and Evaporation Calculation System)

Method 4. Monthly percentage of average maps.

These maps prepared by the Rainfall Section of the Met. Office are drawn for the whole of the UK but presented on A4 size sheets which belie the potential accuracy available, given the very large number of raingauge sites used in the preparation. The national rainfall pattern is well displayed (see Annexe C) but interpolation for spot values needs great care, especially for a month with large percentage variations.

By using a clear overlay with the trial sites marked a consistently accurate series of estimates were obtained with a mean percentage error of 11.3. Two errors of over 80% in low rainfall months, where the trial site failed to reflect the general area value, increased the overall error from an otherwise more reasonable level.

The two main drawbacks in using this method are the delay of around 8 weeks before receipt of the maps and the need for accurate estimates of monthly rainfall averages.

Conclusions

Each of the methods tested is prone to large errors if an unrepresentatively large (or small) fall occurs at the trial site, even if a large part of the uncertainty has been removed by achieving a good area estimate. In the short period chosen for the analysis this occurred in all four areas to different extents. Overall, however, the methods which provided the best area values (2 and 4) also provided the greatest accuracy. Expressing the errors in terms of percentages had, occasionally, disproportionate effects on estimates for dry months. The average annual rainfall weighting factor worked satisfactorily in Methods 1, 2 and 3, and by employing it the increasing error as the distance between sites increases is apparent. The overall bias was restricted to under $\pm$ 5%.

Choice of method for a particular trial will often be determined by other constraints. For example, if a quick estimate is necessary then either a MORECS value can be taken or, if a co-operating recorder can be approached locally, a single site used. If a large number of trial sites were involved then the monthly percentage maps used in conjunction with an overlay would provide accurate estimates with a minimum of effort, but the delay in receipt of the maps could be inconvenient.

If the rainfall amount is in any way critical to an investigation then an average error of 10-15% will be unsatisfactory and an on-site raingauge will be required. Daily, weekly or monthly values may then be recorded. The gauge must be of a Met. Office approved design as it has been shown that gauges of sub-standard design or which are poorly exposed can record even larger errors than those described here (Starr et al 1983).

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Midlands and Western Region
Woodthorne
Wolverhampton

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REFERENCES

Starr, J.R. and Roe, C.P. (1983). Comparisons of commercially available raingauges with a standard 5" gauge. Agricultural Memorandum No 971.

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Monthly Rainfall Estimates (mm)

TABLE 1

	Actual	METHOD 1	2	3	4	Actual	METHOD 1	2	3	4
		NEWPORT AREA					PRESTON AREA			
OCT '81	68	67	72	84	74	192	187	192	172	178
NOV	40	36	34	46	37	138	110	131	113	132
DEC	82	78	82	55	85	67	59	64	83	63
JAN '82	54	45	52	65	41	79	83	85	61	78
FEB	13	12	15	16	17	45	47	51	38	47
MAR	69	62	65	69	69	111	108	117	109	111
APR	34	27	32	29	31	30	31	30	30	28
MAY	24	23	31	29	44	57	51	55	39	53
JUN	89	84	108	92	101	191	179	160	138	149
JUL	34	25	41	48	44	30	22	22	32	34
AUG	58	61	74	63	76	120	151	169	124	147
SEP	80	77	80	76	84	66	79	77	75	76
OCT	58	59	62	61	56	112	103	98	89	104
NOV	59	63	63	77	66	149	163	158	145	157
DEC	59	54	58	68	60	130	149	147	120	126
JAN '83	48	50	50	67	47	126	135	142	131	131
FEB	15	16	15	17	19	33	32	35	33	34
MAR	47	45	47	54	43	91	99	101	97	95
APR	92	91	92	81	105	85	76	88	104	98
MAY	79	75	82	78	89	99	84	92	106	119
JUN	15	15	16	12	27	47	51	50	49	46

	Actual	METHOD 1	2	3	4	Actual	METHOD 1	2	3	4
		WELLESBOURNE AREA					MACCLESFIELD AREA			
OCT '81	53	59	58	57	62	167	173	159	144	174
NOV	33	31	32	31	33	111	127	111	107	110
DEC	62	60	66	67	67	66	87	75	77	68
JAN '82	45	43	48	36	41	81	73	70	58	64
FEB	28	35	31	28	29	23	28	25	28	22
MAR	81	83	81	72	80	100	115	98	102	90
APR	22	23	21	21	21	41	44	37	33	31
MAY	23	32	28	30	27	29	33	26	34	31
JUN	74	89	88	111	92	120	114	122	149	149
JUL	27	24	30	28	29	22	29	29	27	31
AUG	73	83	77	55	68	139	142	134	130	119
SEP	67	66	66	50	66	95	105	97	78	103
OCT	63	64	59	70	61	64	77	67	67	65
NOV	56	56	62	72	58	112	126	115	110	106
DEC	48	51	52	51	52	90	103	96	92	90
JAN '83	50	51	51	44	51	124	130	129	124	120
FEB	17	20	20	20	20	37	39	38	37	38
MAR	37	40	37	35	32	90	97	96	84	85
APR	79	78	82	87	78	91	117	109	95	91
MAY	99	92	99	91	95	82	105	103	104	93
JUN	24	26	28	19	26	28	33	35	23	31

ANNEXE A

NEWPORT

	Gauge No.		Height (m)	AAR (mm)
Newport	432251		64	660
Chetwynd Park	431892	2 km NE	70	724
Chudrington	432335	8 km W	53	610
Lilleshall	432473	5 km S	69	695
MORECS	Square 114	-	92	739

PRESTON (Moor Park)

	Gauge No.		Height (m)	AAR (mm)
Preston (Moor Park)	576634		33	1005
Preston (Ingol)	576670	3 km NW	35	1000
Haighton Res.	576577	5 km NE	80	1072
Preston (Hoghton)	576397	7 km SE	49	970
MORECS	Square 97	-	100	1054

WELLESBOURNE

	Gauge No.		Height (m)	AAR (mm)
Wellesbourne	452036		47	599
Moreton Morrell	452001	3 km E	85	622
Thurlaston (S-u-Avon)	452606	6 km W	41	633
Warwick	451552	8 km N	47	652
MORECS	Square 137	-	108	675

MACCLESFIELD

	Gauge No.		Height (m)	AAR (mm)
Macclesfield	564708		152	915
Rainow	564865	3 km E	248	967
Bottoms Res	564594	4 km SE	201	979
Windyharbour	556423	9 km SW	91	800
MORECS	Square 106	-	246	1068

ANNEX B.

9M

TOTAL RAINFALL (MM)

FOR 40KM X 40KM GRID SQUARES

FOR JUN 1982

X = MISSING VALUE

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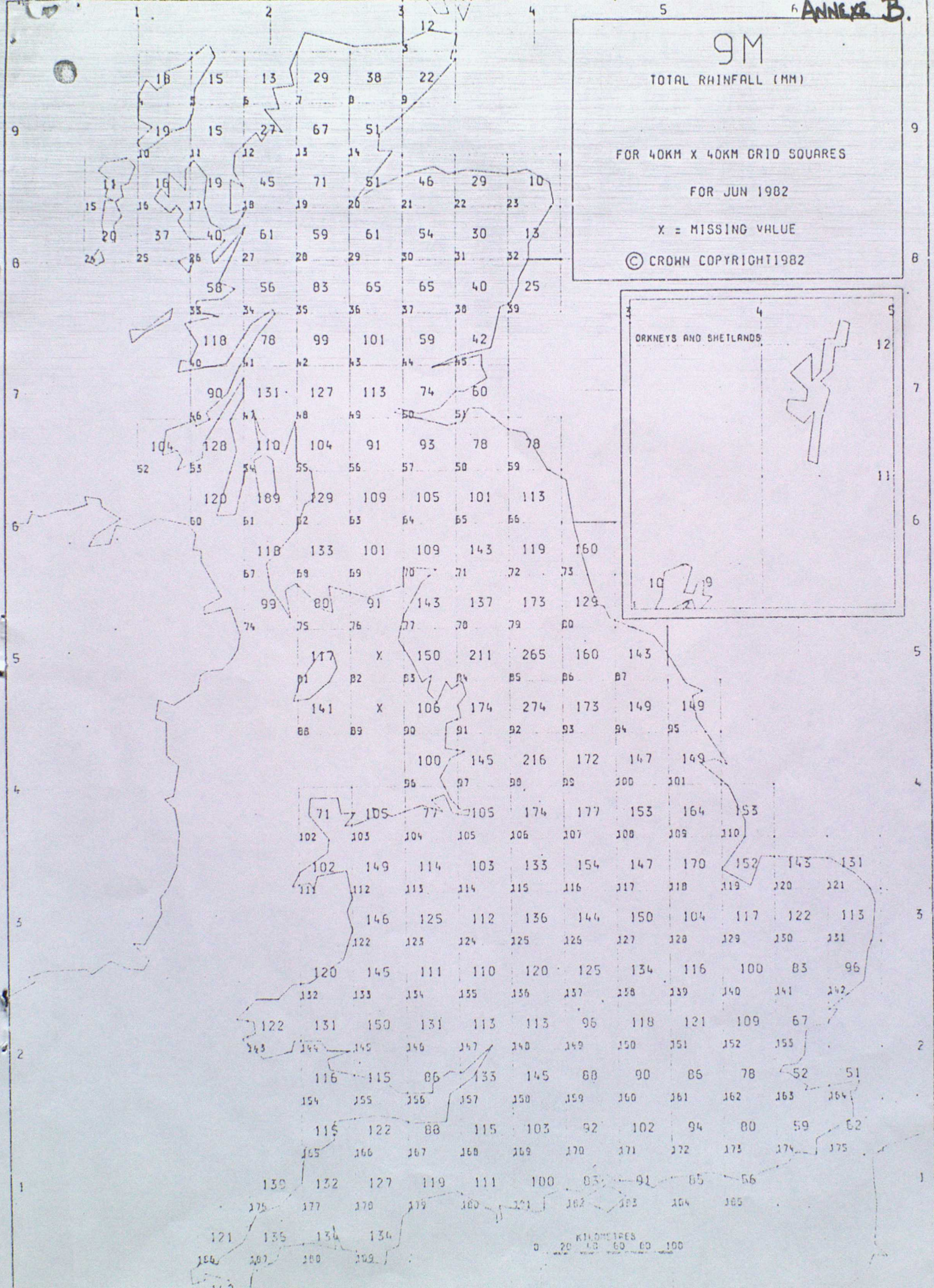
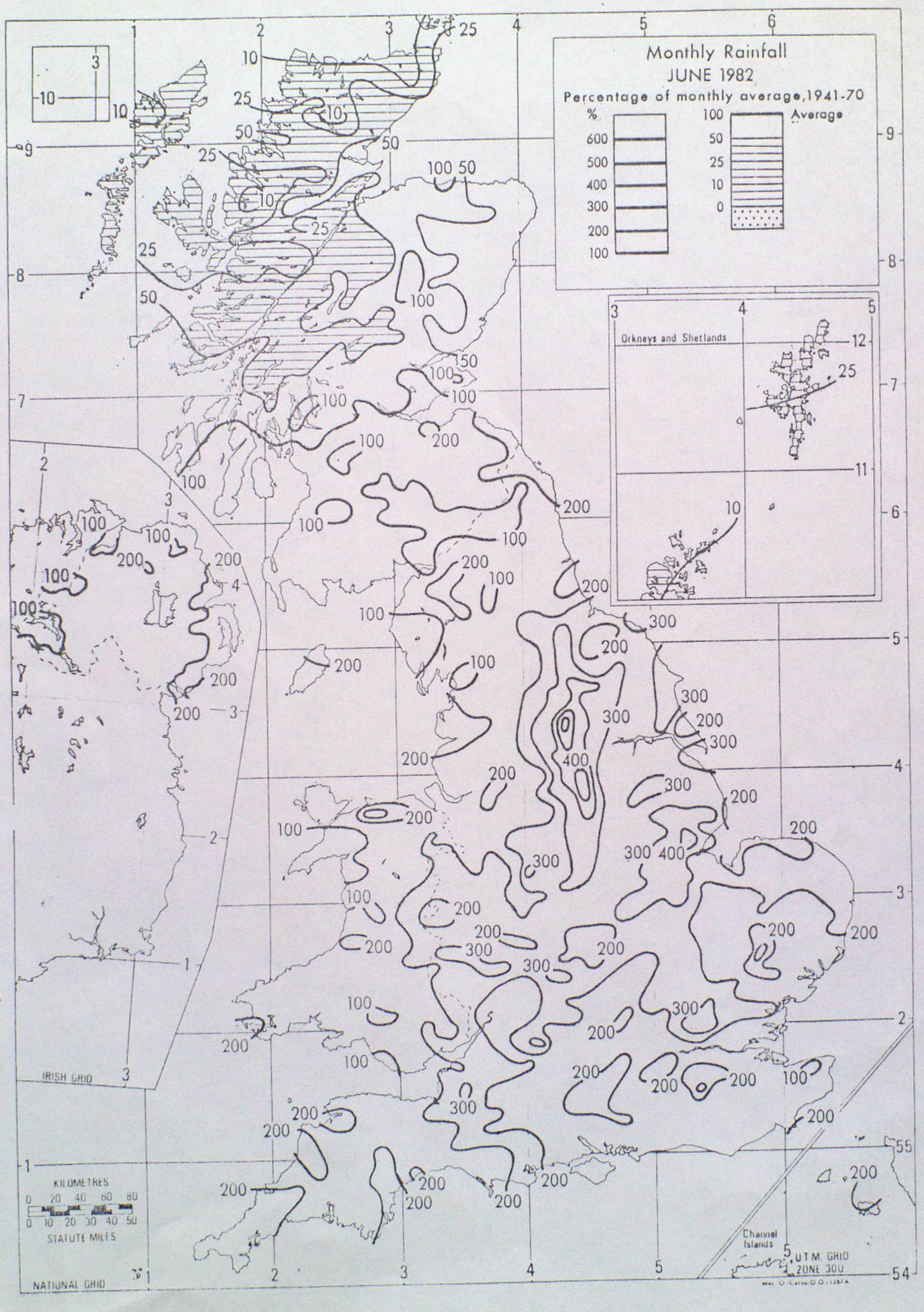


ANNEXE C.


Monthly Rainfall
JUNE 1982
Percentage of monthly average, 1941-70
%
600
500
400
300
200
100
100
50
25
10
0
Average
Orkneys and Shetlands
IRISH GRID
NATIONAL GRID
KILOMETRES
0 20 40 60 80
0 10 20 30 40 50
STATUTE MILES
Channel Islands
UTM GRID
ZONE 30U